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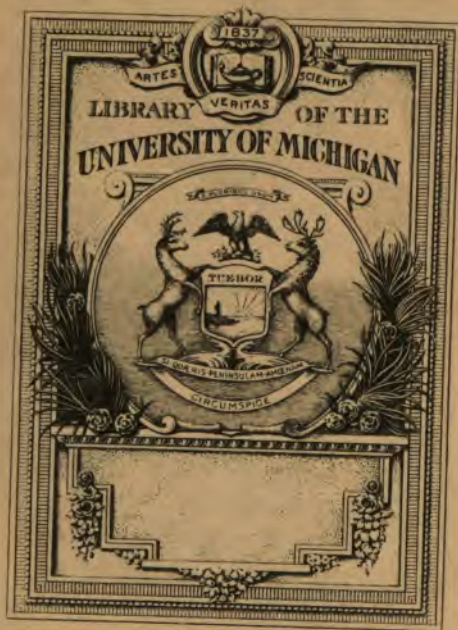
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CHEMICAL PROBLEMS,

WITH BRIEF STATEMENTS OF THE PRINCIPLES INVOLVED.

BY

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1879.

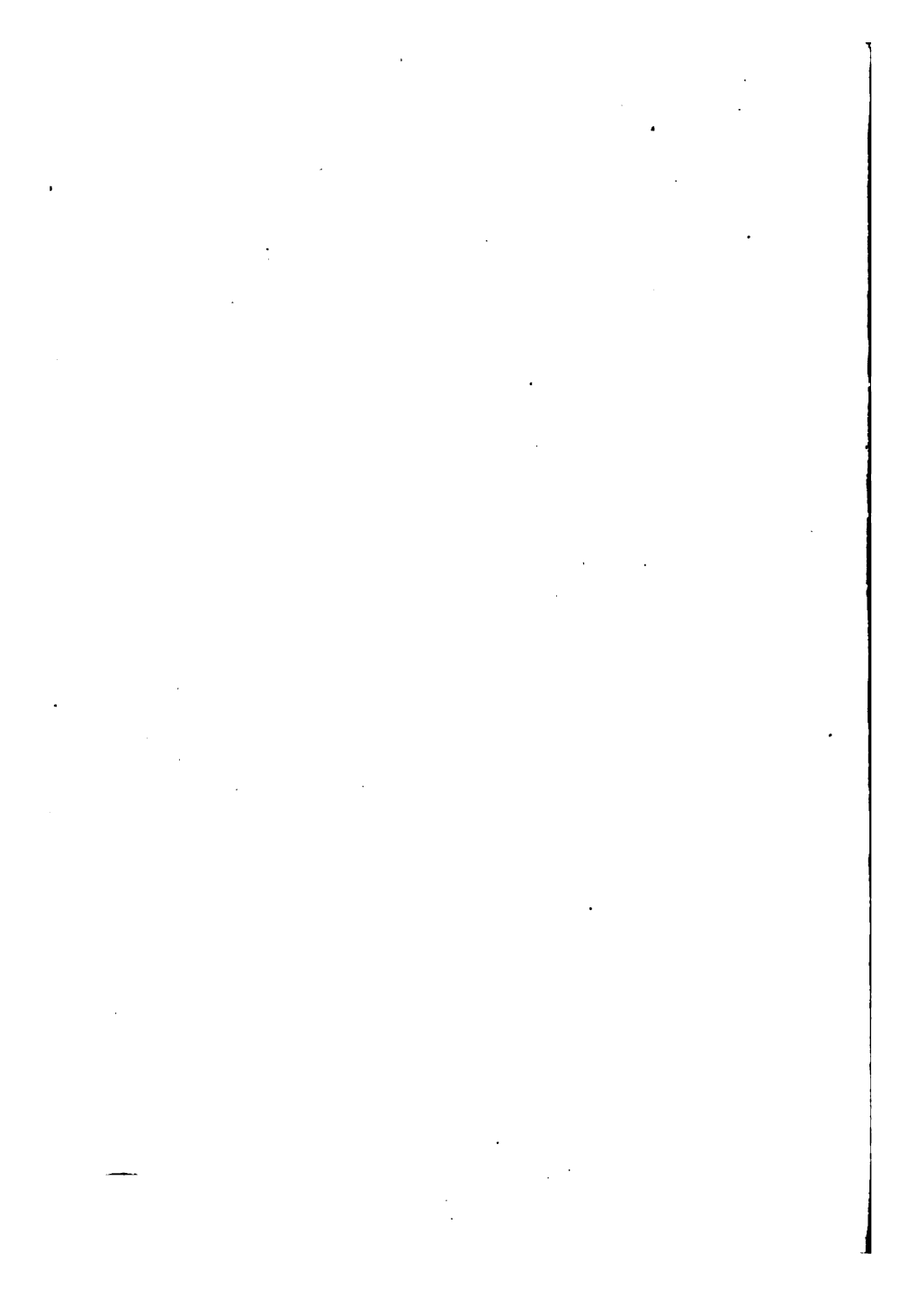
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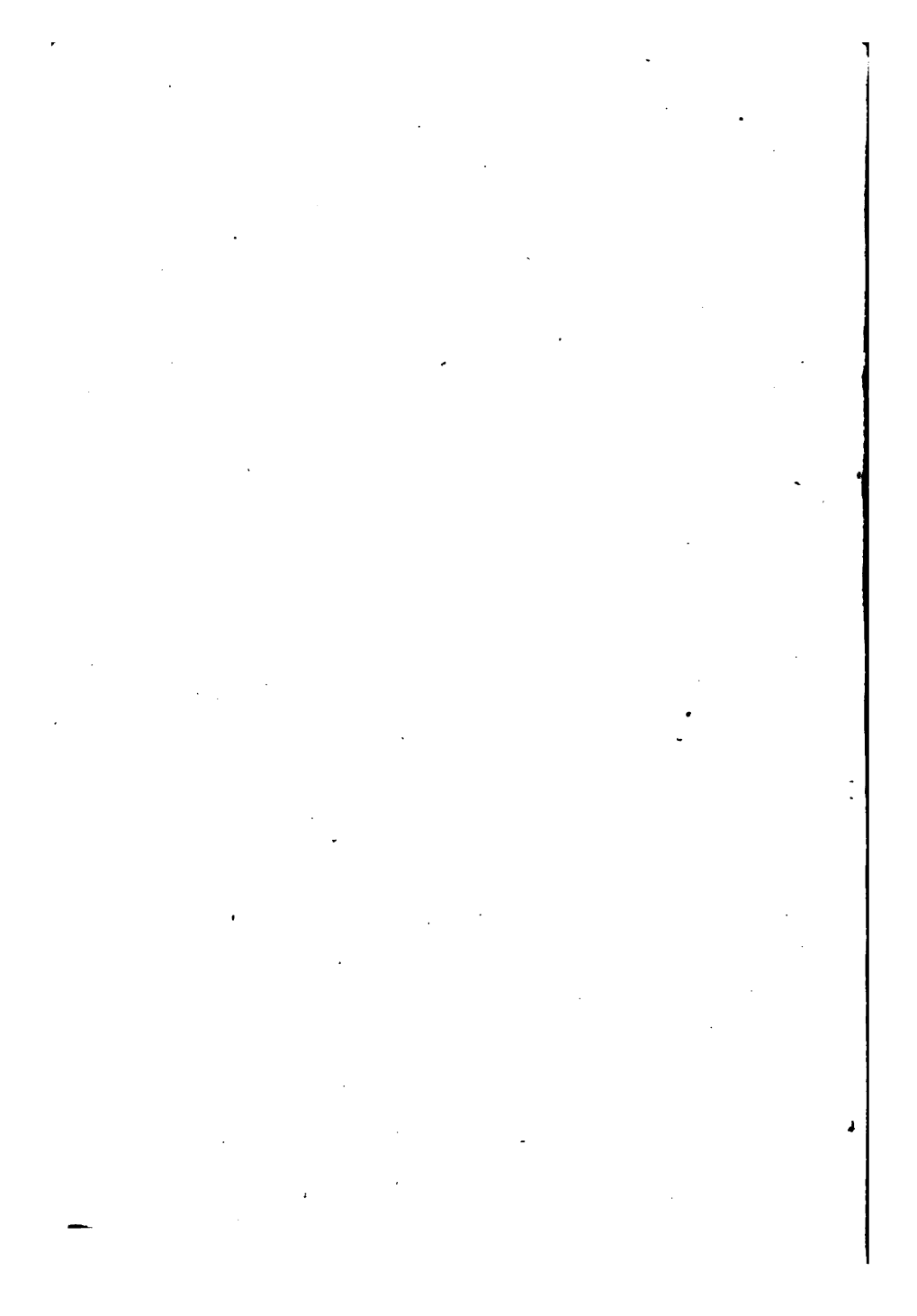
My experience has led me to feel more and more strongly that by no method can accuracy in a knowledge of Chemistry be more surely secured than by attention to the working of well-selected problems.

ROSCOE.



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I.

Volume of Gases Under Varying Pressure.

Mariotte's Law. The temperature remaining the same, the volume of a given quantity of gas is inversely as the pressure to which it is exposed.

The principle is expressed by the proportion

$$P' : P :: V : V' [1]$$

in which V and V' represent the volumes which are exposed to the pressures of P and P' respectively. Usually the pressure to which a gas is exposed, is measured by the barometer, so that H and H' (indicating barometric heights) may be substituted for P and P' in [1], by which we obtain

$$H' : H :: V : V'. [2]$$

The standard pressure is that indicated by the barometric height of 760 m. m. It can easily be shown that the specific gravity of a given quantity of a gas is directly proportional to the pressure to which it is exposed, and that the weight of a given volume of gas is also directly proportional to the pressure to which it is exposed.

1. A volume of gas was found to be equal to 250 c. c. when the height of the barometer was 742 m. m. What would have been the volume, had the barometer stood at 760 m. m.?

By [2], $760 : 742 :: 250 : V' = \text{Ans. } 244.08 \text{ nearly.}$

2. A volume of gas measured 467 c. c. when the barometer stood at 756 m. m. What would it have measured, had the barometer stood at 760 m. m.?

Ans. 464.54+.

8.

3. A volume of air measured 137 c. c. when the barometer stood at 766 m. m. What would it have measured had the barometer stood at 760 m. m.?

138.08⁺ cc. Ans. 138.63 c. c.

4. A volume of hydrogen gas in a bell jar over mercury measured 524 c. c. The mercury in the jar was 54 m. m. above the surface of the mercury in the trough, and the barometer stood at 745 m. m. What would have been the volume if exposed to the standard pressure alone?

Ans. 476.4 c. c.

5. A volume of air in a bell jar over water measured 975 c. c. The water in the jar was 68 m. m. above the water in the trough, and the barometer stood at 756 m. m. What would have been the volume if exposed to the standard pressure, on the supposition that mercury is 13.6 times heavier than an equal volume of water?

Ans. 945.667 c. c.

6. The specific gravity of oxygen under standard conditions is 1.1056 (air=1). What is its specific gravity when the barometer stands at 745 m. m.?

Ans. 1.0838.

7. The specific gravity of ammonia gas under standard conditions is .591. What is its specific gravity when the barometer stands at 750 m. m.?

Ans. .5832.

8. The specific gravity of chlorine is 2.45 under standard conditions. What is the barometric height when the specific gravity is 2.40?

Ans. 744.5 m. m. nearly.

9. One litre of hydrogen under standard conditions weighs .0896 gram. What is the weight of one litre when the barometer stands at 740 m. m.?

Ans. .08724 gram.

• 10. One litre of air under standard conditions weighs 1.2932 grams. What is the weight of 2.5 litres when the barometer stands at 755 m. m.?

Ans. 3.21173 grams.

• 11. Under a pressure of 745 m. m., 1500 c. c. of chlorine weigh 4.67174 grams. What is the weight of one litre under standard pressure?

Ans. 3.1772 grams.

• 12. Under standard conditions, one litre of oxygen weighs 1.4336 grams. What is the pressure when one litre weighs 1.29024 grams?

Ans. 684 m. m.

• 13. Under a pressure of 745 m. m., 1500 c. c. of a gas weigh 1.9762 grams. What is the weight per litre under standard pressure?

Ans. 1.344 grams.

II.

Volume of Gases Under Varying Temperature.

Law of Charles. The pressure remaining the same, the volume of a given quantity of a gas is directly proportional to its absolute temperature.

A gas expands or contracts $\frac{1}{273}$ of its volume at 0°C for every increase or decrease in temperature of 1°C .; hence if a volume of a gas at 0°C . should have its temperature lowered through 273° , the contraction would equal the volume.

This point, (273 below zero C) is called the *absolute zero*, and temperatures reckoned from this point, *absolute temperatures*. The principle is expressed by the proportion

$$T : T' :: V : V' [3].$$

* 14. A volume of air measured 475 c. c. at 27°. What would have been its volume at zero?

$$\text{By } [3], 273+27 : 273+0 :: 475 : V' = \text{Ans. } 432.25.$$

* 15. A quantity of hydrogen gas measured 550 c. c. at 15°. What would have been its volume had its temperature been -10°?

$$273+15 : 273-10 :: 550 : V' = \text{Ans. } 502.257.-$$

* 16. A given weight of air measured 256 c. c. at 34°. What would have been its volume had its temperature been zero?

$$\text{Ans. } 227.648 \text{ c. c.}$$

* 17. A volume of nitrogen measured 3.5 litres at 75°. What would have been its volume had its temperature been 15°?

$$\text{Ans. } 2.9 \text{ litres nearly.}$$

* 18. A volume of gas measured 50 c. c. at 15°. At what temperature would its volume become 44 c. c.?

$$\text{Ans. } -19.56^\circ.$$

* 19. A quantity of gas was measured when its temperature was 12°. At what temperature would its volume be doubled?

$$\text{Ans. } 297^\circ.$$

* 20. An open vessel was heated to 819°. What portion of the air which the vessel contained at 0° remained in it?

$$\text{Ans. } \frac{1}{4}.$$

21. An open vessel was heated till one-half of the gas which it contained at 15° was driven out. What was the temperature of the vessel?

$$\text{Ans. } 303^\circ.$$

III.

Volume of Gases Under Varying Pressure and Temperature.

By combining [2] and [3], we obtain

$$\frac{H': H}{T : T'} \} :: V : V' \text{ [4].}$$

22. A volume of oxygen measured 375 c. c. when the barometer stood at 745 m. m., and its temperature was 17°. What would have been the volume at the standard pressure of 760 m. m., and standard temperature of 0°?

By [4], $\frac{760 : 745}{273 + 17 : 273 + 0} \} :: 375 : V' = \text{Ans. } 346.05 \text{ c. c.}$

23. A volume of hydrogen at a temperature of 15° measured 2.7 litres when the barometer stood at 752 m. m. What would have been its volume had its temperature been 9°, and the barometer stood at 762 m. m.?

Ans. 2.6 litres.

24. The temperature of the air in an open vessel was 11° when the barometer stood at 757 m. m. To what extent would the air expand, should the vessel be heated to 1000° when the barometer stood at 764 m. m.?

Ans. 4.44 times its original volume.

Reduce the following volumes of gas to the standard temperature of 0° and pressure of 760 m. m.:

25. 18 c. c. having a temperature of 14° and under a pressure of 742 m. m.

Ans. 16.72 c. c.

28. 14 c. c. having a temperature of 11° and under a pressure of 763 m. m.

Ans. 13.51 c. c.

27. 2.5 litres having a temperature of 18° and under a pressure of 748 m. m.

Ans. 2.308 litres.

28. 0.18 c. m. having a temperature of 20° and under a pressure of 764 m. m.

Ans. 0.1686 c. m.

29. A volume of gas whose temperature was 15° , measured 1640 cubic inches when the barometer stood at 29.7 inches. What would have been its volume had its temperature been 10° , and the height of the barometer 30.2 inches?

Ans. 1584.84 cubic inches.

IV.

Specific Gravity and Molecular Weight of Gases.

The standard of specific gravity for gases is either air or hydrogen. The molecular weight of a perfect gas or vapor is equal to twice its specific gravity referred to hydrogen. The weight of gases is taken at the standard pressure of 760 m. m. and temperature of zero. The weight of one litre (1000 c. c.) of dry air is 1.2932 grams. The weight of one litre hydrogen (often used as a unit of weight and called *crith*) is .0896 gram.

30. 2.3 litres of oxygen weigh 3.2885 grams. What is its specific gravity referred to air?

$$\frac{3.2885}{1.2932 \times 2.3} = 1.1056.$$

31. Two litres of sulphuretted hydrogen weigh 3.0442 grams. What is its specific gravity referred to air?

Ans. 1.177.

32. One litre of chlorine weighs 3.1683 grams. What is its specific gravity (air=1)?

Ans. 2.45.

33. Four litres of ammonia gas weigh 3.0571 grams. What is its specific gravity (air=1)?

Ans. .591.

Determine the specific gravity referred to hydrogen and the molecular weights of the following gases from the data annexed:

34. Nitrogen, 2 litres weigh 2.5088 grams.

Ans. Specific gravity 14. Molecular wt. 28.

35. Sulphurous oxide, one litre weighs 2.8672 grams.

Ans. Specific gravity 32. Molecular wt. 64.

36. Carbon monoxide, 1500 c. c. weigh 1.8816 grams.

Ans. Specific gravity 14. Molecular wt. 28.

37. Carbon dioxide, 500 c. c. weigh .9856 grams.

Ans. Specific gravity 22. Molecular wt. 44.

38. Marsh gas, 3 litres weigh 2.15 grams.

Ans. Specific gravity 8. Molecular wt. 16.

39. A quantity of gas measuring 5.04675 litres when the temperature is 15° , and pressure 740 m. m. weighs 7.616 grams. What is its molecular weight?

Ans. 34 (very nearly).

40. The specific gravity of a gas was 31.1707 when its temperature was 11° , and under a pressure of 750 m. m. What is its molecular weight?

Ans. 64.

41. Find the specific gravity of alcohol vapor, referred to air, from the following data obtained by Dumas' method:

Weight of glass globe full of air is 50.804 grams when the barometer stands at 747.5 m. m., and the temperature is 18° .
Weight of the globe filled with vapor having a temperature of

167° is 50.824 grams, the height of the barometer at the moment of sealing being 747.6 m. m. The capacity of the globe is 351.5 c. c.

The first step in the above example is to find the weight of the vacuous globe. This is found by subtracting from the weight of the globe full of air, the weight of air contained in the globe, ascertained by calculation from the capacity of the globe, the temperature and pressure of the air and the weight of one c. c. of air under standard conditions.

By [4] we thus reduce 351.5 c. c. of air when the barometer stands at 747.5 m. m., and the temperature is 18° to standard conditions.

$$\left. \begin{array}{l} 760 : 747.5 \\ 273 + 18 : 273 \end{array} \right\} :: 351.5 : V' = 324.328$$

and the weight of 324.328 c. c. of air is .41942 gram. (The weight of one c. c. of air is .0012932 gram.)

$$50.804 - .41942 = 50.38458 = \text{weight of vacuous globe.}$$

The second step is to find the weight of the vapor, which is readily done by subtracting the weight of the vacuous globe from the weight of the globe full of vapor, 50.824—50.38458 = .43942 gram = weight of vapor.

The third step is to find the weight of a volume of air equal to that of the vapor, and having the same temperature and under the same pressure. We must now find the capacity of the globe, taking into account the expansion due to the increase of temperature, which causes no appreciable error when the increase is small. One c. c. of glass increases .00003 c. c. when the temperature is raised one degree; hence 351.5 c. c. of glass at a temperature of 167° become $.00003 \times 351.5 \times 167 + 351.5 = 353.261$ c. c. Proceeding as in the first step,

$$\left. \begin{array}{l} 760 : 747.6 \\ 273 + 167 : 273 \end{array} \right\} :: 353.269 : V' = 215.9328$$

and 215.9328 c. c. of air weigh .279244 grams. The final step

is to divide the weight of the vapor by the weight of the air, $.43942 \div .279244 = 1.574$, which is the specific gravity of alcohol vapor.

42. Find the specific gravity of camphor vapor referred to air, from the following data :—weight of glass globe full of air 50.134 grams when the barometer stands at 742 m. m., and the temperature is 13.5° : weight of the globe filled with vapor having a temperature of 244° 50.842 grams, the height of the barometer at the moment of sealing being 742 m. m.: capacity of the globe 295 c. c.

Ans. 5.371.

43. From the data given in the 41st problem find the specific gravity of alcohol vapor, hydrogen being taken as the standard.

Ans. 22.712.

V.

To Find Atomic Weights.

44. Find the atomic weight of hydrogen from the following data. In the second column is given the molecular weight of the substances, and in the third column the weight of hydrogen in the molecules :

Hydrochloric Acid.....	36.5	1
Hydrobromic Acid.....	81	1
Hydrogen Gas.....	2	2
Water	18	2
Formic Acid.....	46	2
Phosphoretted Hydrogen.....	34	3
Ammonia Gas.....	17	3
Acetic Acid.....	60	4
Olefiant Gas.....	28	4
Marsh Gas.....	16	4
Alcohol.....	46	6
Ether.....	74	10

It is inferred that as 1 is the weight of the smallest mass of hydrogen known to exist in a molecule of any substance, that this smallest mass is the atom, and hence that 1 is the atomic weight of hydrogen.

45. Find the atomic weight of carbon and the number of atoms of carbon in each molecule of the substances named :

	Molecular Weight.	Weight of Carbon in Molecule.
(a) Carbon Dioxide.....	44.....	12
(b) Carbon Disulphide....	76.....	12
(c) Olefiant Gas.....	28.....	24
(d) Alcohol.....	46.....	24
(e) Propylic Hydride.....	44.....	36
(f) Ether.....	74.....	48
(g) Amylic Hydride.....	72.....	60

Ans. Atomic weight of carbon is 12.

(a) and (b) have each one atom of carbon, (c) and (d) each two atoms, (e) three atoms, (f) four atoms, and (g) five atoms.

46. Find the atomic weight of oxygen and the number of atoms of oxygen in each molecule of the following substances from the annexed data :

	Molecular Weight.	Weight of Oxygen in Molecule.
(a) Water.....	18.....	16
(b) Carbon Monoxide....	28.....	16
(c) Carbon Dioxide.....	44.....	32
(d) Phosphoric Oxide....	142.....	80
(e) Sulphuric Oxide.....	80.....	48
(f) Nitric Acid.....	63.....	48
(g) Sulphuric Acid.....	98.....	64
(h) Sodic Bisulphate.....	222.....	112

Ans. Atomic weight of oxygen is 16.

(a) and (b) have each one atom of oxygen, (c) two atoms, (d) five atoms, (e) and (f) each three atoms, (g) four atoms, and (h) seven atoms.

47. In 100 parts of lime (calcic oxide) there are 71.43 parts of calcium and 28.57 parts of oxygen. The atomic weight of oxygen is 16, and there is reason to believe that each molecule of lime is a group of two atoms, one each of calcium and oxygen. What is the atomic weight of calcium?

Ans. $28.57 : 71.43 :: 16 : 40$ = weight of the one atom of calcium.

48. In 100 parts of calcic chloride there are 36.03 parts of calcium and 63.97 parts of chlorine. The atomic weight of calcium is 40, and there is reason to believe that each molecule of the calcic chloride is a group of three atoms, one of calcium and two of chlorine. What is the atomic weight of chlorine?

Ans. 35.5.

49. In 100 parts of stannic chloride there are 54.61 parts of chlorine and 45.39 parts of tin. The atomic weight of chlorine is 35.5. What is the atomic weight of tin, on the supposition that each molecule of stannic chloride is a group of five atoms, one of tin and four of chlorine?

Ans. 118.

50. In 100 parts of stannic sulphide there are 35.17 parts of sulphur and 63.83 parts of tin. The atomic weight of tin is 118. What is the atomic weight of sulphur, on the supposition that each molecule of stannic sulphide is a group of three atoms, one of tin and two of sulphur?

Ans. 32.

51. Calculate the atomic weight of phosphorus from the following data: In 100 parts of phosphoric oxide there are 43.66 parts of phosphorus and 56.34 parts of oxygen. Each molecule is a group of seven atoms, two of phosphorus and five of oxygen, and the atomic weight of oxygen is 16.

Ans. 31.

52. A compound of silver and chlorine, weighing 121.4993 grams, was produced by heating 91.462 grams of silver in a stream of chlorine gas. What is the atomic weight of silver, on the supposition that one atom of silver unites with one atom of chlorine?

Ans. 108.09.

53. Copper oxide when heated in a stream of hydrogen, lost 59.789 grams of oxygen and yielded 67.282 grams of water. Calculate the atomic weight of oxygen on the supposition that one atom of oxygen unites with two atoms of hydrogen to form a molecule of water.

Ans. 15.959 very nearly.

54. A compound of mercury and oxygen, weighing 118.3938 grams yielded 109.6308 grams of mercury. Calculate the atomic weight of mercury on the supposition that one atom of oxygen unites with one atom of mercury to form a molecule of the compound.

Ans. 200.17.

55. Find the atomic weight of silver from the following data:—molecular weight of silver chloride 143.5: in 100 parts of silver chloride there are 75.26 parts (very nearly) of silver: specific heat of silver .057.*

Weight of silver in the molecule is $143.5 \times 75.26 \div 100 = 108$, which may represent the weight of one, two, three or more atoms. Divide 6.34 by .057 (the specific heat of silver) and we will obtain approximately the atomic weight of silver. $6.34 \div .057 = 111$, which shows that 108 represents the weight of one atom of silver.

* It has been found that the product of the atomic weight of an elementary solid by its specific heat varies from 5.6 to 6.9—the mean being very nearly 6.34. Boron, carbon and silicon are exceptions.

56. Find the atomic weight of lead from the following data :—molecular weight of lead sulphide 249 : in 100 parts of lead sulphide there are 84.13 parts of lead : specific heat of lead .0314.

Ans. 207.

57. The molecular weight of arseniuretted hydrogen is 78 In 100 parts there are 96.15 parts of arsenic, and the specific heat of arsenic is .0814. What is the atomic weight of arsenic?

Ans. 75.

58. The molecular weight of carbon disulphide is 76, and 100 parts yield 84.21 parts of sulphur ; the specific heat of sulphur is .2026. What is the atomic weight of sulphur, and how many atoms of sulphur in a molecule of the carbon. disulphide ?

Ans. Atomic weight 32, and number of atoms of sulphur in the molecule 2.

59. From the following data find the atomic weight of sodium and the number of atoms each of sodium and chlorine in a molecule of sodium chloride (common salt):—in 100 parts of sodium chloride there are 60.68 parts of chlorine and 39.32 parts of sodium ; atomic weight of chlorine 35.5 ; specific heat of sodium .2934.

Ans. Atomic weight of sodium 23, and a molecule of sodium chloride contains one atom each of chlorine and sodium.

60. From the following data find the atomic weight of manganese and the number of atoms in the compound analyzed:—an analysis of an oxide of manganese yielded 69.62 parts of manganese and 30.38 parts of oxygen in 100 ; atomic weight of oxygen 16 ; specific heat of manganese .1217.

Ans. Atomic weight of manganese 55. Number of atoms in a molecule of the compound five, three of oxygen and two of manganese.

VI.

Calculation of Molecular Weights from the Symbol.

61. What is the molecular weight of zinc sulphate ZnSO_4 ? The molecular weight of a compound is equal to the sum of the weights of the atoms composing it. ZnSO_4 has a molecular weight 161.2. (161.2 being equal to $65.2 + 32 + 4 \times 16$).

The atomic weights of the elements are given in Table II in the appendix.

Find the molecular weights of the following compounds by means of the annexed symbols:

- | | |
|---|-------------|
| 62. Water, H_2O . | Ans. 18. |
| 63. Phosphoric Oxide, P_2O_5 . | Ans. 142. |
| 64. Borax, $\text{Na}_2\text{B}_4\text{O}_7$. | Ans. 202. |
| 65. Potassium Chlorate, KClO_3 . | Ans. 122.6. |
| 66. Lead Sulphate, PbSO_4 . | Ans. 303. |
| 67. Kakodyl, $\text{C}_4\text{H}_{12}\text{As}_2$. | Ans. 210. |
| 68. Ethylic Silicate, $\text{C}_8\text{H}_{20}\text{O}_4\text{Si}$. | Ans. 208. |
| 69. Kreatin, $\text{C}_4\text{H}_9\text{N}_3\text{O}_2 + \text{H}_2\text{O}$. | Ans. 149. |
| 70. Gypsum, $\text{CaSO}_4 + 2\text{H}_2\text{O}$. | Ans. 172. |
| 71. Alum, $\text{K}_2\text{Al}_2\text{S}_4\text{O}_{24} + 24\text{H}_2\text{O}$. | Ans. 949. |

VII.

Symbol, Weight and Volume.

72. What is the weight of one litre of carbon dioxide at standard pressure and temperature? Symbol is C O_2 .

The molecular weight of carbon dioxide ($12 + 2 \times 16$) is 44, and hence its specific gravity referred to hydrogen is 22. One litre of hydrogen weighs .0896 gram, and the weight of one litre of carbon dioxide is $.0896 \times 22 = 1.9712$ grams.

Calculate the weight of the following gases at standard pressure and temperature :

73. Two litres of hydrochloric acid gas. Symbol H Cl .
Ans. 3.27 + grams.

74. 1500 c. c. of hydrogen sulphide. Symbol $\text{H}_2 \text{ S}$.
Ans. 2.2848 grams.

75. 250 c. c. of chlorine. Symbol Cl_2 .
Ans. .7952 gram.

76. Five litres of ethene. Symbol $\text{C}_2 \text{ H}_4$.
Ans. 6.272 grams.

77. What is the weight of five litres of alcohol vapor having a temperature of 127° and under a pressure of 750 m. m.? Symbol of alcohol $\text{C}_2 \text{ H}_6 \text{ O}$.

Ans. 6.94 grams.

78. What is the volume of a kilogram of carbon monoxide (C O) at the standard temperature and pressure?

Ans. 797.114 litres.

79. What is the volume of 225 grams of hydrogen sulphide ($\text{H}_2 \text{ S}$) at the standard temperature and pressure?

Ans. 141.143 litres.

80. What is the volume of 20 grams of carbon dioxide (C O_2) at the standard temperature and pressure?

Ans. 10.146 litres.

81. What is the volume of 82.88 grams of the vapor of vinic ether ($\text{C}_4 \text{H}_{10} \text{O}$) at the temperature of 147° , and under a pressure of 740 m. m.?

Ans. 39.5 litres.

VIII.

Symbol and Composition.

82. Calculate the percentage composition of water $\text{H}_2 \text{O}$.

First find the molecular weight of water ;

Weight of atoms hydrogen=2.

" " " oxygen=16.

Molecular weight of water=18.

Then for every 18 parts of water there must be 2 parts of hydrogen and 16 parts of oxygen, and the percentage composition or amount of each constituent in 100 parts of the compound is readily found by the proportion

$18 : 2 :: 100 : x = 11.11$ = the percentage of hydrogen.

$18 : 16 :: 100 : x = 88.89$ = the percentage of oxygen.

The following proportion of general application may be readily deduced:

$m : w :: M : W$. [5].

In which m = molecular weight of the substance ; w = weight of the atoms of each element or constituent of the molecule ; M = weight of the substance ; W = weight of each element or constituent.

Calculate the percentage composition of the following compounds :

- 83. Carbon dioxide, C O_2 .
 Ans. Carbon 27.27. Oxygen 72.73.
84. Ammonia, $\text{H}_3 \text{N}$.
 Ans. Hydrogen 17.65. Nitrogen 82.35.
85. Ferric Oxide, $\text{Fe}_2 \text{O}_3$.
 Ans. Iron 70. Oxygen 30.
- 86. Alcohol, $\text{C}_2 \text{H}_6 \text{O}$.
 Ans. Carbon 52.18. Hydrogen 13.04. Oxygen 34.78.
87. Acetic acid, $\text{C}_2 \text{H}_4 \text{O}_2$.
 Ans. Carbon 40. Hydrogen 6.67. Oxygen 53.33.
88. Calcium sulphate, Ca SO_4 .
 Ans. Calcium 29.41. Sulphur 23.53. Oxygen 47.06.
89. Cream of tartar, $\text{K H}_5 \text{C}_4 \text{O}_6$.
 Ans. Potassium 20.79. Hydrogen 2.66. Carbon 25.52. Oxygen 51.03.
90. Ferrous Sulphate, $\text{Fe SO}_4 + 7\text{H}_2 \text{O}$.
 Ans. Iron 20.15. Sulphur 11.51. Oxygen 23.02. Water 45.32.
91. Common alum, $\text{K}_2 \text{Al}_2 4 \text{SO}_4 + 24 \text{H}_2 \text{O}$.
 Ans. Potassium 8.24. Aluminum 5.77. Sulphur 13.49. Oxygen 26.98. Water 45.52.
92. How much iodine can be obtained from 236 grams of potassic iodide (K I)?
 Ans. 180.45 grams.
93. How many grams of oxygen and of hydrogen can be obtained by the decomposition of 27 grams of water ($\text{H}_2 \text{O}$)?
 Ans. 24 grams of oxygen and 3 of hydrogen.
94. How many grams of oxygen can be obtained by the decomposition of 100 grams of mercuric oxide (Hg O)?
 Ans. 7.407 grams.

95. How many pounds of phosphorus in 265 pounds of calcic phosphate ($\text{Ca}_3 \text{P}_2 \text{O}_8$)?

Ans. 53 pounds.

96. It is required to find the weight of iron in 1000 kilograms of ferric oxide ($\text{Fe}_2 \text{O}_3$).

Ans. 700 kilos.

97. How many grams of potassic chlorate (K Cl O_3) are needed to produce, by decomposition, 100 grams of oxygen?

Ans. 255.4 grams.

98. How many pounds of pure limestone (Ca CO_3) are needed to produce one ton of quick lime (Ca O)?

Ans. 3671.428 lbs.

99. How many grams of copper can be obtained from 1337 grams of cupric sulphate ($\text{Cu SO}_4 + 6\text{H}_2 \text{O}$)?

Ans. 317 grams.

100. If 1337 grams of cupric sulphate yield 317 grams of copper, and the atomic weight of the copper in one molecule is 63.4, what is the molecular weight of cupric sulphate?

Ans. 267.4.

101. If 1357 grams of cupric sulphate yield 317 grams of copper, and its molecular weight is 267.4, how many atoms of copper are there in a molecule of the sulphate?

Ans. 1.

102. How much potassic iodide (K I) will be required to yield 78 grams of iodine?

Ans. 102 grams.

103. Ferric oxide contain 30 per cent. of oxygen, and its molecule three atoms of oxygen. What is its molecular weight?

Ans. 160.

104. Sodium chloride (common salt) contains 39.32 per cent of sodium, and its molecular weight is 58.5. What is the atomic weight of sodium, on the supposition that there is but one atom of sodium in the molecule of salt?

Ans. 23.

105. By heating 15 grams of pure silver in a stream of chlorine, 19.9306 grams of silver chloride are produced. The weight of the atoms of silver in a molecule of silver chloride is 108. What is the molecular weight of silver chloride and the number of atoms of chlorine in a molecule?

Ans. Molecular weight 143.5. No. of atoms of chlorine 1.

106. One gram of water (H_2O) will yield how many cubic centimetres of hydrogen and oxygen, having a temperature of 20° when the barometer stands at 765 m. m.? The specific gravity of oxygen referred to hydrogen is 16.

By [5], one gram of water will yield .1111 grain of hydrogen and .8889 gram of oxygen. The volume of .1111 gram of hydrogen at 0° and under a pressure of 760 m. m. is found $(.1111 \div .0000896)$ to be equal to 1240 c. c. The volume which the 1240 c. c. of hydrogen will occupy when the temperature is 20° , and under a pressure of 765 m. m., is found by [4].

$$\left. \begin{array}{l} 273 : 273 + 20 \\ 765 : 760 \end{array} \right\} :: 1240 : V' = 1322.144 \text{ c. c.}$$

The volume of .8889 gram of oxygen at 0° and under a pressure of 760 m. m., is found $(.8889 \div (.0000896 \times 16))$ to be equal to 620 c. c. The volume which the 620 c. c. of oxygen will occupy when the temperature is 20° and under a pressure of 765 m. m., is found by [4] as above, to be equal to 661.072 c. c.

Ans. Hydrogen 1322.144 c. c. Oxygen 661.072 c. c.

107. How many c. c. of chlorine at a temperature of 15° and under a pressure of 770 m. m., can be obtained from 15 grams of silver chloride (Ag Cl)? The specific gravity of chlorine referred to hydrogen is 35.5.

Ans. 1214.708 c. c.

108. How many grams of mercuric oxide (Hg O.) can be obtained by the union of mercury with 1500 c. c. of oxygen, measured at a temperature of 18° when the barometer stands at 755 m. m.?

Ans. 27.055 grams.

109. How many grams of mercury, and how many litres of chlorine measured at a temperature of 15° when the barometer stands at 770 m. m., are consumed in the manufacture of 100 grams of corrosive sublimate (Hg Cl_2)?

Ans. 8.576 litres of chlorine. 73.80 grams of mercury.

IX.

To Find the Symbol of a Compound.

110. The specific gravity of the vapor of acetic acid is 30. In 100 parts of the acid there are 40 parts of carbon, 6.67 parts of hydrogen and 53.33 parts of oxygen. What is the symbol of acetic acid?

The molecular weight is $(30 \times 2) = 60$.

By [5], $60 : w :: 100 : 40$. $w = 24$ = weight of carbon atoms.

$60 : w :: 100 : 6.67$. $w = 4$ = weight of hydrogen atoms.

$60 : w :: 100 : 53.33$. $w = 32$ = weight of oxygen atoms.

$24 \div 12 = 2$ = the No. of atoms of carbon in a molecule.

$4 \div 1 = 4$ = the No. of atoms of hydrogen in a molecule.

$32 \div 16 = 2$ = the No. of atoms of oxygen in a molecule.

Hence the symbol is $\text{C}_2 \text{H}_4 \text{O}_2$.

111. The specific gravity of steam is 9. The percentage composition of water is hydrogen 11.11, oxygen 88.89. What is the symbol of water?

Ans. H_2O .

112. The specific gravity of alcohol vapor is 23. In 100 parts there are 52.18 parts of carbon, 13.04 parts of hydrogen and 34.78 parts of oxygen. What is the symbol of alcohol?

Ans. C_2H_6O .

113. The percentage composition of ammonia is nitrogen 82.353, hydrogen 17.647. Its specific gravity is 8.5. What is its symbol?

Ans. H_3N .

114. The specific gravity of the vapor of ethylene chloride is 49.5, and its percentage composition is, carbon 24.24, hydrogen 4.04, chlorine 71.72. What is its symbol?

Ans. $C_2H_4Cl_2$.

115. Calculate the symbol of stannic chloro-triethide from the following data:—percentage composition: chlorine 14.76, carbon 29.94, hydrogen 6.24, tin 49.06, specific gravity of vapor 120.25.

Ans. $Cl_4C_6H_{15}Sn$.

116. Calculate the symbol of ethylic silicate from the following data:—specific gravity of vapor 104: percentage composition: carbon 46.15, hydrogen 9.62, oxygen 30.77, silicon 13.46.

Ans. $C_8H_{20}O_4Si$.

117. In 100 parts of a compound of manganese and oxygen there are 63.22 parts of manganese, and 36.78 parts of oxygen. What is the simplest symbol possible?

From Table II in the appendix, the atomic weights of manganese and oxygen are found to be 55 and 16 respectively. $63.22 \div 35 = 1.149$, and $36.78 \div 16 = 2.299$. As $1.149 : 2.299 :: 1 : 2$, the simplest ratio between the number of manganese and oxygen atoms is $1 : 2$; hence the simplest symbol is Mn O_2 .

118. A compound of iron and oxygen yielded a percentage composition of iron 70, and oxygen 30 per cent. What is its simplest symbol?

Ans. $\text{Fe}_2 \text{O}_3$.

119. The percentage composition of ammoniac chloride is, nitrogen 26.17, hydrogen 7.48, chlorine 66.35. What is the simplest symbol possible?

Ans. $\text{N H}_4 \text{Cl}$.

120. Find the simplest symbol for acid potassic carbonate from the following data:—percentage composition: hydrogen 1, potassium 39.06, carbon 11.99, oxygen 47.95.

Ans. H K CO_3 .

121. In 100 parts of sodic sulphate there are 32.39 parts of sodium, 22.54 parts of sulphur, and 45.07 parts of oxygen. What is its simplest symbol?

Ans. $\text{Na}_2 \text{SO}_4$.

122. Calcic phosphate has in 100 parts, 38.71 parts of calcium, 20.00 parts of phosphorus, and 41.29 parts of oxygen. What is its simplest symbol?

Ans. $\text{C}_3 \text{P}_2 \text{O}_8$.

123. In 100 parts of crystallized ferrous sulphate there are 20.15 parts of iron, 11.51 parts of sulphur, 23.02 parts of oxygen, and 45.32 parts of water. What is its simplest symbol?

Ans. $\text{Fe SO}_4.7\text{H}_2 \text{O}$.

124. What is the simplest symbol of morphia, its percentage composition being, carbon 71.58, hydrogen 6.66, nitrogen 4.91, oxygen 16.85?

Ans. $C_{17}H_{19}NO_3$.

125. On analysis, 18 grams of a compound of iron and sulphur yielded 8.4 grams of iron and 9.6 grams of sulphur. What is its simplest symbol?

Ans. FeS_2 .

126. On analysis, 48 grams of a compound yielded 37.21 grams of lead, 2.16 grams of carbon, and 8.63 grams of oxygen. What is its simplest symbol?

Ans. $PbCO_3$.

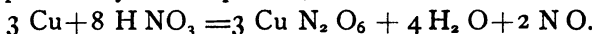
127. What is the simplest symbol of a substance, 27 grams of which, on analysis, yielded 2.64 grams of magnesium, 3.51 grams of sulphur, 7.02 grams of oxygen, and 13.83 grams of water?

Ans. $MgSO_4 \cdot 7H_2O$.

X.

Equation, Weight and Volume.

128. How much nitric acid (HNO_3) is required to produce 150 grams of copper nitrate (CuN_2O_6)? The reaction is expressed by the equation,



Since the molecular weights represent the relative weights of the substances used, the same ratio exists between the weight of the molecules (3×187.4) of copper nitrate, and the weight of the molecules (8×63) of nitric acid as exists between the weight of copper nitrate and of nitric acid.

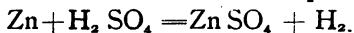
$$3 \times 187.4 : 8 \times 63 :: 150 : x = \text{Ans. } 134.47 \text{ grams.}$$

The following proportion is easily deduced :

$$n m : n' m' :: W : W', [6]$$

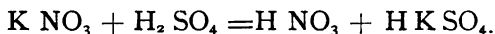
In which n represents the number of molecules, and m the molecular weight of the substance given, n' the number of molecules, and m' the molecular weight of the substance required, W the weight of the substance given and W' the weight of the substance required.

129. How many grams of zinc sulphate, (Zn SO_4) can be obtained by the action of 200 grams of sulphuric acid ($\text{H}_2 \text{SO}_4$) upon zinc? The reaction is expressed by the equation,



Ans. 328.98 grams.

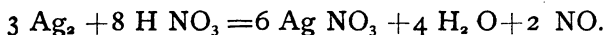
130. Nitric acid (H NO_3) is prepared by the action of sulphuric acid ($\text{H}_2 \text{SO}_4$) upon potassium nitrate (K NO_3). The following equation expresses the reaction :



Calculate (a) how much nitric acid may be produced from 500 grams of potassium nitrate, (b) how much sulphuric acid would be required to decompose the 500 grams of potassium nitrate, and (c) how much acid potassium sulphate (H K SO_4) would be produced.

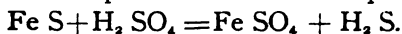
Ans. (a) 311.56+grams, (b) 484.66+grams,
(c) 673.09+grams.

131. How many grams of silver and of nitric acid (H NO_3) are required to produce 240 grams of silver nitrate (Ag N O_3)? The equation is



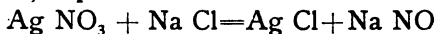
Ans. 152.47 grams of silver and 118.588
grams of nitric acid.

132. 75 grams of ferrous sulphide (Fe S) treated with sulphuric acid ($\text{H}_2 \text{SO}_4$) will yield how many grams of ferrous sulphate (Fe SO_4) and of hydrogen sulphide ($\text{H}_2 \text{S}$)? How many grams of sulphuric acid will be required?



Ans. 129.545 grams of ferrous sulphate,
28.977 grams of hydrogen sulphide,
83.523 grams of sulphuric acid.

133. A solution contains 30 grams of silver nitrate (Ag NO_3). How much common salt (Na Cl) is required to decompose the silver nitrate, and how much silver chloride (Ag Cl) is produced?

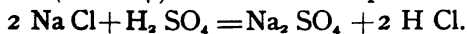


Ans. 10.32 grams of salt, and 25.32 grams
of silver chloride.

134. How many grams of sulphuric acid ($\text{H}_2 \text{SO}_4$) and of nitre (K NO_3) are required to make 250 grams of nitric acid. For equation see problem 130

Ans. 388.9 grams of sulphuric acid and
401.2 grams of nitre.

135. How much hydrochloric acid gas (H Cl) can be obtained by treating one kilogram of common salt (Na Cl) with sulphuric acid ($\text{H}_2 \text{SO}_4$)? How much sulphuric acid will be needed?



Ans. 623.93 grams of hydrochloric acid gas,
and 837.6 grams of sulphuric acid.

By adopting the crith (weight of one litre of hydrogen = .0896 gram) as the unit of weight for gases and hydrogen as the standard for specific gravity, we obtain

$$\frac{W}{.0896} = V \times \text{specific gravity},$$

in which W = weight in grams, and V = volume in litres. In

the proportion $n m : n' m' :: W : W'$, if we divide the third and fourth terms by .0896, and the substitute for the fourth term its value as found above and for m' its value ($2 \times$ specific gravity) we easily deduce the proportion

$$n m : 2 n' :: \frac{W}{.0896} : V, [7]$$

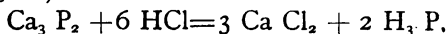
in which n represents the number of molecules, and m the molecular weight of the substance given; n' the number of molecules of the required gaseous substance; W the weight in grams of the given substance, and V the volume in litres of the required gas.*

136. How many litres of hydrochloric acid gas (HCl) can be made by the use of 575 grams of common salt (Na Cl)?



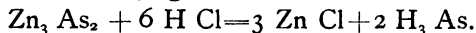
$$\text{By } [7] 2 \times 58.5 : 2 \times 2 :: \frac{575}{.0896} : V = \text{Ans. } 219.48 \text{ litres.}$$

137. How many litres of hydrogen phosphide ($\text{H}_3 \text{ P}$) can be made by the use of 250 grams of calcium phosphide ($\text{Ca}_3 \text{ P}_2$)?



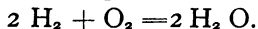
$$\text{Ans. } 61.323 \text{ litres.}$$

138. How many litres of hydrogen arsenide ($\text{H}_3 \text{ As}$) can be made with 640 grams of zinc arsenide?



$$\text{Ans. } 82.674 + \text{ litres.}$$

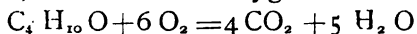
139. How many litres of hydrogen and of oxygen are necessary to produce ten cubic centimetres of water ($\text{H}_2 \text{ O}$)?



$$\text{Ans. } 12.4 \text{ litres of hydrogen, and } 6.2 \text{ litres of oxygen.}$$

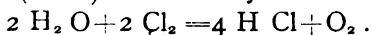
* All gases are supposed to be at the standard temperature and under standard pressure, unless otherwise stated.

140. By the combustion of one cubic centimetre of ether ($C_4 H_{10} O$) having a specific gravity of .715, how many c. c. of carbon dioxide ($C O_2$) and of aqueous vapor ($H_2 O$) are produced, and how much oxygen is consumed?



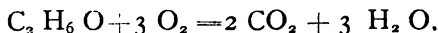
Ans. 862.693 c. c. of carbon dioxide,
1294.039 c. c. of oxygen,
1078.366 c. c. of aqueous vapor.

141. How many litres of hydrochloric acid gas ($H Cl$) and of oxygen can be made by the use of 875 grams of water ($H_2 O$)? How many litres of chlorine are required?



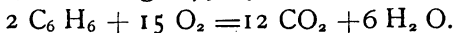
Ans. 2170.1388 litres of hydrochloric acid,
542.5347 litres of oxygen,
1058.0694 litres of chlorine.

142. How many litres oxygen are required to burn (i. e. unit with) 1.5 kilograms of alcohol ($C_2 H_6 O$) and how many litres of carbon dioxide (CO_2) and of aqueous vapor ($H_2 O$) are formed by the combustion?



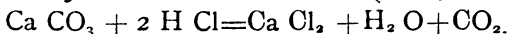
Ans. 2183.618 litres of oxygen,
1455.754 litres of carbon dioxide,
2183.618 litres of aqueous vapor.

143. How many litres of air are necessary to burn 15 grams of benzole ($C_6 H_6$)? Composition of air is, oxygen 20.96, and nitrogen 79.04 volumes in 100.



Ans. 105.889 litres.

144. How many grams of chalk ($Ca CO_3$) are required to yield 15 litres of carbon dioxide (CO_2)?



Ans. 67.2 grams.

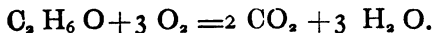
145. How many grams of common salt (Na Cl) are required to make 520 litres of hydrochloric acid gas (HCl)? For equation see problem 136.

Ans. 1362.816 grams.

146. How many grams of zinc and how many of pure sulphuric acid (H_2SO_4) are required to make 1875 c. c. of hydrogen? For equation see problem 129.

Ans. 5.4768 grams of zinc, 8.232 grams of sulphuric acid.

147. How many litres of oxygen are required to burn two litres of alcohol vapor (C_2H_6O) and how many litres of carbon dioxide (CO_2) and of aqueous vapor (H_2O) are produced?

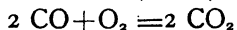


From the equation it appears that for every one molecule of alcohol vapor consumed there are three molecules of oxygen used, and two molecules of carbon dioxide and three of aqueous vapor produced. As "equal volumes of all gases contain the same number of molecules," it follows the volumes are proportioned to the number of molecules. Hence for every two litres of alcohol vapor, there are required six litres of oxygen, and there are produced four litres of carbon dioxide and six of aqueous vapor.

148. How many litres of benzole vapor (C_6H_6) are required to produce by combustion, 24 litres of carbon dioxide (CO_2) and how much aqueous vapor (H_2O) is produced, and how many litres of oxygen are consumed? For equation see problem 143.

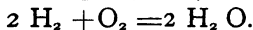
Ans. 4 litres of benzole vapor,
12 litres of aqueous vapor,
30 litres of oxygen.

149. By the burning of 6 litres of carbon monoxide (C O) how many litres of oxygen are consumed, and how many of carbon dioxide (C O₂) are produced?



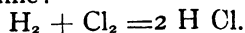
Ans 3 litres of oxygen, 6 litres of carbon dioxide.

150. Ten litres of hydrogen in burning will require how many litres of oxygen, and produce how many litres of aqueous vapor (H₂ O)?



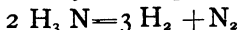
Ans. 5 litres of oxygen, 10 litres of aqueous vapor.

151. 250 c. c. of chlorine are mixed with 150 c. c. of hydrogen. How many c. c. of hydrochloric acid gas (H Cl) are produced, which gas remains in excess and what is its volume?



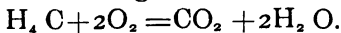
Ans, 300 c. c. of H Cl. 100 c. c. of Cl.

152. How many c. c. of hydrogen and of nitrogen can be obtained by decomposing one litre of ammonia?



Ans. 1500 c. c. of H. 500 c. c. of N.

153. How many litres of air are necessary to burn 10 litres of marsh gas?



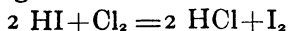
Composition of air by volume, O = 20.96

N = 78.04

100.00

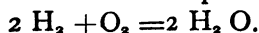
Ans. 95.42 nearly.

154. After liberating by chlorine the iodine in 265 c. c. of hydroiodic acid gas, there were 318 c. c. of a mixture of hydrochloric acid and chlorine gases; what was the volume of each gas in the mixture?



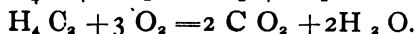
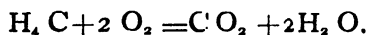
Ans. 265 c. c. of HCl. 53 c. c. of Cl.

155. 30 litres of hydrogen were mixed with 18 litres of oxygen and chemical union produced; how much aqueous vapor having a temperature of 140°C ., and pressure of 760 m. m. was obtained? Which gas remained in excess, and what was its volume at the temperature and pressure given above?



Ans. 45.3846+ of H_2O . 4.53846+ of O .

156. How many c. c. of air are necessary to burn a mixture containing 375 c. c. of marsh gas (H_4C) and 450 c. c. of olefiant gas (H_4C_2) and how much carbon dioxide and aqueous vapor are produced?



Ans. 10219.084 c. c. nearly of air. 1275. c. c. of carbon dioxide. 1650. c. c. of aqueous vapor.

XI.

Diffusion of Gases.

Molecular weights of gases are inversely proportional to the square of the velocity of diffusion.

The diffusive power of air being taken as unity, Graham found that the diffusive power of hydrogen is 3.83.

157. The diffusive power of a gas was found by Graham to be .812 (air being taken as unity). Analysis shows that in 100 parts of the gas there are 27.273 parts of carbon and 72.727 parts of oxygen. What is its molecular weight, symbol and specific gravity?

By preceding as in problem 117, we find that for every atom of carbon there are two atoms of oxygen, and hence that the molecular weight is 44, 88, 132 or some other multiple of 44. From the law of diffusion of gases given above

$$.812^2 : 3.83^2 :: 2 : x = 44.4 +$$

which fixes 44 as the molecular weight (2 is the molecular weight of hydrogen). The symbol, CO_2 , and specific gravity, 22, are then easily found.

158. The rate of diffusion of a gas as compared with air is found to be 1.344. On analysis, 100 parts yielded 75 parts of carbon and 25 parts of hydrogen. What is its molecular weight, symbol and specific gravity?

Ans: Molecular weight 16, symbol H_4C ,
specific gravity 8.

159. The rate of diffusion of a gas is found to be 1.0149. Analysis shows that in 100 parts there are 85.714 parts of carbon and 14.286 parts of hydrogen. What is its molecular weight, specific gravity and symbol?

Ans. Molecular weight 28, specific gravity 14,
Symbol H_4C_2 .

160. The velocity of diffusion of nitrogen is 1.0143. How many atoms of nitrogen in a molecule?

Ans. Two.

161. The velocity of diffusion of oxygen is .9487. How many atoms of oxygen in a molecule?

Ans. Two.

162. What is the rate of diffusion of sulphurous oxide (SO_2)?

Ans. .677+

163. What is the rate of diffusion of hydrogen arsenide (H_3As)?

Ans. .6133 nearly.

XII.

Calorific Power.

The calorific power of a substance is measured by the number of kilograms of water which are raised one degree centigrade by the burning of one kilogram of the substance in oxygen of air. The following table expresses the calorific power of a number of substances:

Hydrogen.....	34462	Tin.....	1144
Carbon	8080	Copper	602
Phosphorus	5747	Carbon Monoxide.	2400
Sulphur.....	2221	Marsh Gas.....	13063
Iron.....	1576	Olefiant Gas.....	11858
Zinc.....	1301	Ether.....	9027
		Alcohol.....	7184

When the combustible contains oxygen and hydrogen, the hydrogen available as fuel is that which is in excess of that required to form water with the oxygen present. The latent heat of the aqueous vapor formed, and of the hygroscopic water present, must be deducted from the calorific power of substance burnt.

164. Calculate the calorific power of coal which has the following percentage composition: carbon 88.42, hydrogen 5.61, oxygen 5.97.

It is readily seen from its composition that one kilogram of the coal contains 884.2 grams of carbon, 56.1 grams of hydrogen and 59.7 grams of oxygen. The quantity of hydrogen combined with oxygen as water ($59.7 \div 8$) is 7.46 grams, leaving hydrogen available for fuel, $56.1 - 7.46 = 48.64$ grams.

The quantity of water formed by burning 56.1 grams of hydrogen (56.1×9) is 504.9 grams.

884.2 grams of carbon yield 7144.336 units of heat,
48.64 grams of hydrogen " 1676.232 " " "

Total..... 8820.568 " " "

Heat latent in 504.9 grams of
water ($.5049 \times 606.5$), is ... 306.222

Calorific power of the coal. ... 8514.346 units.

165. Calculate the calorific power of dried peat from the following per centage composition :—carbon 62.54, hydrogen 6.81, oxygen 29.24, nitrogen 1.41 (nitrogen and other non-combustibles do not affect the calorific power).

Ans. 5790 nearly.

166. Calculate the calorific power of wood having the following per centage composition :—carbon 40, hydrogen 4.8, oxygen 32.8, hygroscopic water 20, ashes 2.4.

Ans. 3090 nearly.

167. How many grams of water can be heated one degree centigrade by the burning of five grams of hydrogen?

Ans. 172.31 grams.

168. How many grams of phosphorus are required to heat one kilogram of water from zero to boiling point?

Ans. 17.4 grams.

169. How much water can be heated from zero to 20° by the combustion of three grams of sulphur?

Ans. .3331 grams.

170. How many litres of hydrogen are required to raise the temperature of three kilograms of water from zero to boiling point?

Ans. 97.157 litres.

171. The mechanical equivalent of heat being 423 kilogram metres, what mechanical power is developed by the combustion of one kilogram of charcoal?

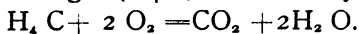
Ans. 3417840 kilogram metres.

XIII.

Calorific Intensity.

Calorific intensity is the maximum temperature developed in the process of combustion. It is found by dividing the calorific power by the sum of the products arising from multiplying the relative weights of the substances produced, by their specific heats.

172. From the following data find the calorific intensity of marsh gas (H_4O) burnt in oxygen.



Calorific power of marsh gas is 13063. Specific heat of carbon dioxide (CO_2) is .2164. Specific heat of steam (H_2O) is .4805.

From the equation it is easily found that one kilogram of marsh gas produces by combustion 2.75 kilograms of CO_2 and 2.25 kilograms of H_2O .

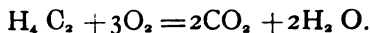
$$\text{Calorific intensity of marsh gas} = \frac{13063}{2.75 \times .2164 + 2.25 \times .4805} = 7793.1 \text{ Ans.}$$

173. What is the calorific power of marsh gas burnt in air? Specific heat of nitrogen is .244. Equation and other data is in the preceeding problem. N. B. When burnt in air the inert nitrogen of the air must be regarded as one of the products. From the equation it is found that one kilogram of H_4C consumes, in burning, 4 kilograms of oxygen. Air is composed of oxygen 23.2 parts to nitrogen 76.8 parts.

$$23.2 : 76.8 :: 4 : 13.24 = \text{the nitrogen.}$$

$$\text{Ans. } 2662.2,$$

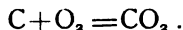
174. What is the calorific intensity of olefiant gas ($H_4 C_2$) when burnt in oxygen? When burnt in air?



Calorific power of $H_4 C_2$ is 11858. Specific heat of CO_2 , $H_2 O$ and nitrogen as in the two preceeding problems.

Ans. Burnt in oxygen 9136.3, in air 2915.4.

175. What is the calorific intensity of charcoal when burnt in oxygen? When burnt in air?



Calorific power of carbon is 8080. Specific heat of CO_2 and nitrogen same as above.

Ans. Burnt in oxygen 10173.9, in air 2737.9.

176. Calculate the calorific intensity of hydrogen burnt in oxygen and in air. $2H_2 + O_2 = 2H_2 O.$

Specific heat of $H_2 O$ and nitrogen as above.

N. B. When hydrogen is burnt under ordinary conditions the aqueous vapor is not condensed and hence its calorific power is less than that given in the table. One part hydrogen yields nine parts vapor. The latent heat of the vapor at zero is 606.5; hence the calorific power of hydrogen burnt under ordinary conditions is $34462 - (606.5 \times 9) = 29003.5$

Ans. Burnt oxygen 6706.87, in air 2688.47.